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Evaluating the impacts of transport backcasting scenarios with multi-criteria analysis

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A R T I C L E I N F O

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A B S T R A C T

Scenario analysis and backcasting methods have been used to determine sustainable transport futures, often with a clearly defined process and the use of experts. This paper diverges from this commonly used approach by presenting a more collaborative and unstructured framework to backcasting that allows the experts to have a much greater part in defining the process and the outcomes. The focus is on the evaluation stage that is operationalised by a multi-criteria analysis (MCA) where the experts themselves have the opportunity to discuss, rank and evaluate the policy packages. The spatial context (Andalusia in Spain) is taken as the laboratory, and regional and local policy-makers are engaged in a series of workshops facilitating an open deliberative process, where MCA is combined with face-to-face discussions, and both of them are integrated with transport scenario analysis. This 'collaborative appraisal framework' consists of presenting the methodological process, the identification of sustainability impacts, the ranking of those impacts according to three different policy pathways (lower carbon emissions, technological innovation, and urban compactness), as well as commenting on the feasibility, acceptability and potential barriers of such policy options. The paper ends with comments on the usefulness of open-ended and participatory approaches in transport backcasting studies, in particular the use of MCA in identifying and evaluating transport decisions.

1. Introduction

The backcasting approach has been increasingly used in transport to illustrate what policies might be introduced to help achieve challenging future targets on climate change, pollution and resources used (Hickman and Banister, 2014). Its distinctiveness lies in taking a normative view of desirable endpoints in the future, and then combining policy packages (e.g. Low emission vehicles; Technological innovation; Liveable cities) that provide different pathways to reach the desired transport futures (Åkerman and Hojer, 2006; Vergragt and Quist, 2011). A number of different stages during the backcasting process can be identified (Banister and Hickman, 2013). The first is the "visioning phase", that establishes desirable endpoints in the longer-term contrasting with the business-as-usual (BAU) projection (Soria-Lara and Banister, 2017a). The second stage is the "policy packaging", based on elaborating a series of policy packages that might help in reaching the images of desirable futures, with detailed pathways and timelines for implementation (Soria-Lara and Banister, 2017b). The third stage is the "appraisal phase", focused on assessing the wider impacts of transport policy-pathways against environmental, social and economic issues, as well as the feasibility, acceptability, and barriers of

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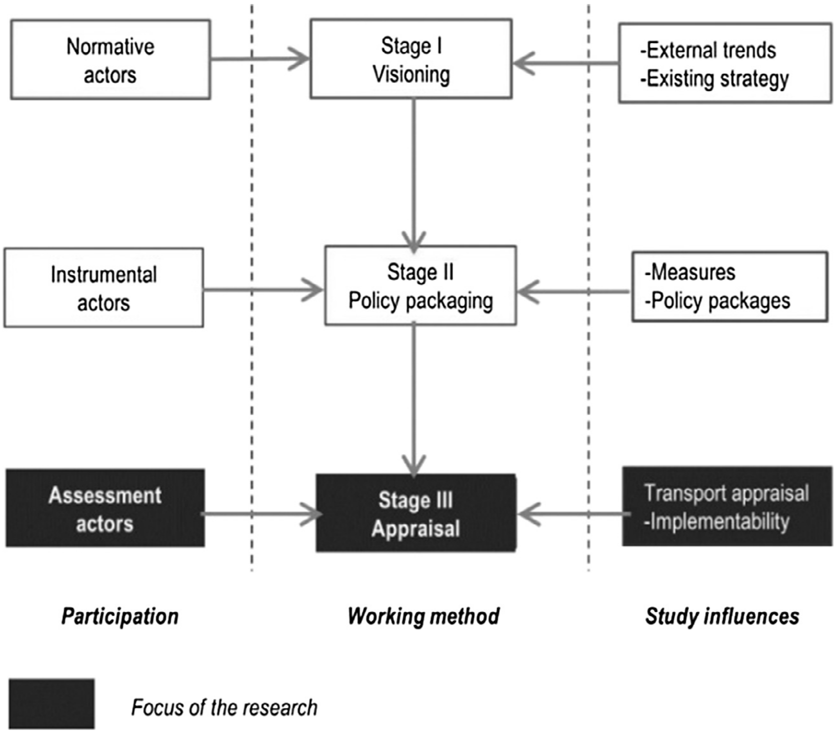

Fig. 1. The structure of the backcasting process.
Adapted from Banister and Hickman., 2013 p. 286.

such policy trajectories (Hickman et al., 2012). The “appraisal phase” of transport backcasting scenarios is the main focus of this paper (Fig. 1).

The academic literature on transport backcasting studies has traditionally focused more on developing innovations on the phases of “visioning” and “policy-packaging” than on the “appraisal phase” (Hickman et al., 2012). As a consequence of this, there has been a gap between academic backcasting studies and real transport practice – the implementation gap (Banister and Hickman, 2013). This means that backcasting is seen as an essentially academic exercise with low level of application as appraisal is not fully addressed. The focus of transport backcasting applications has been to concentrate on the visualisation of desired futures and the subsequent creation of policy-pathways schemes. Under this structure, a narrow group of actors are involved to help identify the drivers of change, the policy measures and the packages to be used. Issues relating to policy-schemes implementation, value, and acceptability are not normally part of that process (Ashina et al., 2012; Markus and Jonsson, 2006; Mattila and Antikainen, 2011; Schade and Schade, 2005; Winyuchakrit et al., 2011). Moreover, the rigid structure of the backcasting process constrains its implementation against the emergence in real practice of collaborative planning approaches, as these are more unstructured, and mainly based on interactions between stakeholders and multiples professional domains (Habermas, 2007; Innes and Booher, 2010; Soria-Lara and Banister, 2018). In sum, the lack of a practical framework for assisting policy-makers in deciding which policy-pathway should be followed potentially reduces the practical usefulness of the scenarios. The assessment of transport backcasting scenarios by using multi-criteria analysis (MCA) is seen here as a promising solution for the following reasons.

Firstly, MCA has been traditionally and successfully used in the field of transport to solve complex decision problems by constructing a hierarchy of criteria for assessment (Gerçek et al., 2004; Wang et al., 2014). Secondly, MCA can be used to rank the likelihood that a range of sustainability impacts (environmental, social, and economic) can be generated for the implementation of the proposed policy pathways in the longer-term (Hickman et al., 2012). Thirdly, MCA can be easily combined with other participatory methods, triggering a more flexible assessment framework that facilitates the engagement a wide range of stakeholders during the assessment process (Zubaryeva et al., 2012b; Vermote et al., 2014). This last point is central in the context of shifting the paradigm towards more collaborative planning approaches, primarily based on stakeholders’ participation and interaction (Bertolini, 2007).

Based on these important issues, this paper has developed a collaborative framework for the “appraisal phase” of transport backcasting studies. It is based on combining MCA with other participatory methods, and their integration with transport scenario analysis. This facilitates the creation of a “collaborative appraisal framework” that can assist policy-makers in deciding how the implementation of transport policy schemes can be made more central to the scenario building process. The context of the transport

sector in Andalusia (Spain) is used as a case study, where there is a clear desire to achieve sustainable transport goals by 2050. The collaborative process is based on three sequential phases: (i) A face-to-face workshop, in which policy-makers have determined potential sustainability impacts (environmental, social and economic) of a series of Andalusian transport future images together with policy pathways to reach those desired endpoints (lower carbon emissions; technological innovation; urban compactness); (ii) MCA is then used to rank the sustainability impacts produced by each policy pathway; (iii) A face-to-face workshop, in which policy-makers discussed the feasibility, acceptability, and potential barriers to implementation of policy pathways in the region of Andalusia. The incorporation of MCA in this "collaborative appraisal framework" is as a learning instrument that provides additional insights to policy-makers on the relative sustainability impacts for each policy-pathway devised. For this reason, the application of MCA is an intermediate step between the initial and the final implementation face-to-face workshops. A total of 36 policy-makers from regional and local governments in Andalusia took part in the process.

Section 2 outlines the background to the research, as well as a desired transport future for Andalusia and a set of policy trajectories to reach this endpoint by 2050. These transport scenarios (visioning + policy pathways) provide the basis for the "collaborative appraisal framework", which is the main focus of this paper. Section 3 presents the research design, including a detailed description of the collaborative process. Section 4 shows the main results, while Section 5 closes the paper with some comments, reflections and concluding remarks.

2. Background and context

2.1. MCA and transport scenario analysis

MCA techniques have been used in many transport policy studies to address complex decision problems where policy-makers are faced with multiple conflicting criteria (Nogués and González-González, 2014; Sun et al., 2015; Vreeker et al., 2002; Tzeng et al., 2005). But there has only been more limited attention paid to combining MCA with transport scenario analysis (Lambert et al., 2012; Wang et al., 2014), and in particular with the backcasting approach (Hickman et al., 2012). However, MCA is presented here as a promising tool when the business-as-usual projection is no longer appropriate, and when transport policies must be assessed with a view to longer-term sustainable outcomes.

Studies that combine MCA with transport scenarios can be further divided into bottom-up and top-down approaches. Bottom-up approaches mean that sustainability impacts and goals of transport policy scenarios are collectively defined by a set of actors before applying MCA techniques, following a collaborative and sequential process (Vermote et al., 2014; Wang et al., 2014; Zubaryeva et al., 2012a; Zubaryeva et al., 2012b). Top-down approaches start with the definition of sustainability impacts and goals by politicians and/or the research team, and then use these to decide which actors should be included in the MCA process (Gardziejczyk and Zabicki, 2014; McDonald et al., 2001; Nijkamp et al., 2007).

Four main types of MCA applications combined with transport scenario analysis can be identified: (i) CO_2 emissions reduction targets that pay special attention on assessing the effects of different policy trajectories (Hickman et al., 2012); (ii) Transport infrastructure integration focused on several issues such as economic development at the regional level (Gardziejczyk and Zabicki, 2014), vulnerability to climate change effects (Lambert et al., 2004), and land use integration (Vermote et al., 2014); (iii) Transport provision based on assessing scenarios where transport provision is improved (Gerçek et al., 2004; Nijkamp et al., 2007); (iv) Transport-technology penetration paying special attention to the implementation of electric vehicles (Zubaryeva et al., 2012b) and advances in transport telematics (McDonald et al., 2001)

In summary, the present research provides an in-depth study focused on the appraisal phase of backcasting studies, primarily using a (bottom-up) collaborative methodology that involves regional and local policy-makers. Then MCA techniques are used to rank potential impacts of three different policy trajectories against a set of sustainability policy goals (environmental, social, and economic), aimed to facilitate mitigation of expected climate change impacts.

2.2. The region of Andalusia: desired futures and policy pathways

A desired transport future for Andalusian has been created by 2050, exploring the preferences and the concerns from the perspective of Andalusian society (Fig. 2). A participatory process has combined a Delphi analysis and semi-structured interviews from a wide range of Andalusian stakeholders. In total, 20 stakeholders took part during the Delphi process including two participation rounds, while another 20 stakeholders with similar profiles to the Delphi process took part during semi-structured interviews. Differences and similarities between the Delphi process and semi-structured interviews resulted in the storyline of the transport desired future in Andalusia. In contrast to the BAU-projection, the summarised storyline of the desired Andalusian transport future is based on (a detailed version can be seen in Soria-Lara and Banister, 2017a): (i) fundamental changes in Andalusian economic model; (ii) decreasing coastal tourism reducing both air and car traffic; (iii) preferences for railway transport at the regional level; (iv) a higher implementation of low emission vehicles; (v) more liveable cities, including strong preferences for walking and cycling; (vi) increasing the number of multi-modal transport facilities.

To reach the transport future by 2050, Soria-Lara and Banister (2017b) have developed a set of three policy pathways, following a participatory process where participants (practitioners from different professional domains and policy-makers) firstly clustered a long

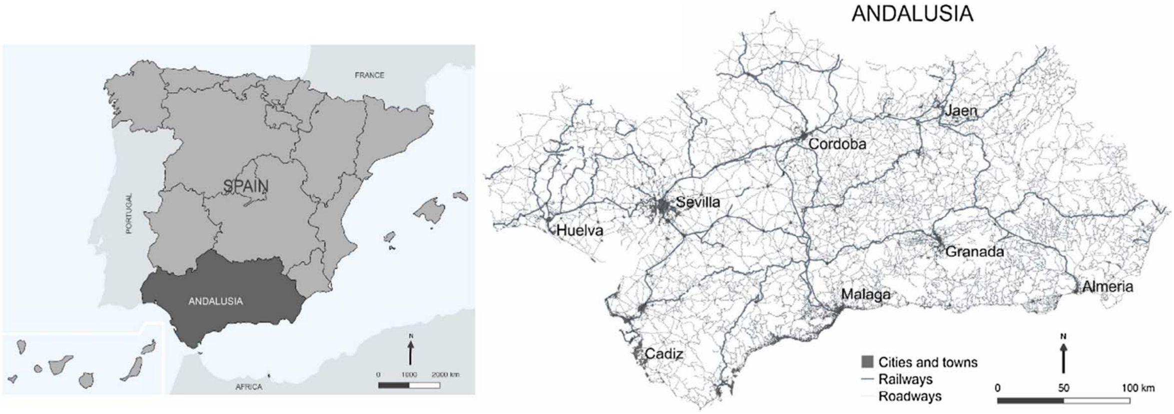

Fig. 2. Case study location.

list of 53 individual policies into 10 policy packages (Table 1), and then those policy packages were combined to be consistent with the three policy pathways:

- The pathway ***lower carbon emissions*** consisted of the combination of five policy packages. The highest priority was given to *PP5 Multi-modality* and *PP10 Infrastructure investments*, while an intermediate priority was given to the following PPs: *PP7 Non-motorised modes, PP1 Low emission vehicles* and *PP4 Freight transport.*
- The pathway ***technological innovation*** consisted of the combination of four policy packages. The highest priority was given to two PPs: *PP1 Low emission vehicles* and *PP2 ICT*. A second level of priority was given to *PP4 Freight transport* and *PP8 Traffic management*.
- The pathway ***urban compactness*** consisted of the combination of four policy packages. The highest priority was given to four PPs: *PP5 Multi-modality, PP6 Liveable cities, PP7 Non-motorised modes* and *PP8 Traffic management*. An intermediate level of priority was given to *PP10 Infrastructure investments*.

Table 1
Description of policy packages (PPs).
Source: Soria-Lara and Banister (2017b).

Policy packages	
PP1. Low Emission Vehicles. It focuses largely on hybrid technologies and lean burn engines. It also pursues additional benefits if alternative fuels are used in conjunction with petrol and diesel hybrids and conventional internal combustion engines. There is a major role here for the motor industry and the regional government fostering the purchase of hybrid and electric vehicles.	*PP6. Liveable cities*. This package focuses on using urban form and the planning system to support sustainable transport, with public transport oriented developments, green belts, as well as a new strategic planning model that facilitates the integration between land use and the transport system.
PP2. ICT. It explores the potential to modify travel patterns and reduce carbon emissions from ICT developments. These measures are mainly targeted at personal and freight travel.	*PP7. Non-motorised modes*. It aims at promoting lower-emissions mobility and focused on pedestrianisation and the promotion of cycling infrastructures. This package is mainly targeted at personal travel.
PP3. Pricing regime. It has a double objective: (i) Reorienting car taxes towards more environmental friendly schemes; (ii) Making the public transport system cheaper. These measures are mainly targeted at personal travel.	*PP8. Traffic management*. This package covers three main purposes: (i) Ecological driving (e.g. decreasing speed limits); (ii) Smarter choices (e.g. implementing company transport plans); (iii) lower carbon mobility (e.g. limiting circulation to motorcycles). These measures are mainly targeted at personal and freight travel.
PP4. Freight transport. There is a wide range of measures under this package from subsidiarity (fostering local production and reducing freight travel distance) to implementing hybrid and electric technologies for urban delivery.	*PP9. Public awareness.* The aim of this package is to increase the awareness of citizens concerning major transport impacts. The set of measures integrated in this package cover from campaigns for car sharing and ecological driving habits to traveller information. This package is mainly targeted at personal travel.
PP5. Multimodality. It covers a set of individual measures focused mainly on increasing the interconnections between the different transport modes: private and public modes, individual and collective modes, motorised and non-motorised modes. Moreover, these measures aim at incrementing the transport network efficiency.	*PP10. Infrastructure investments*. This package focuses on using infrastructure investments to support sustainable transport, with higher investments in rail infrastructures, high-occupancy vehicles lanes, etc. It is mainly targeted at personal and freight travel.

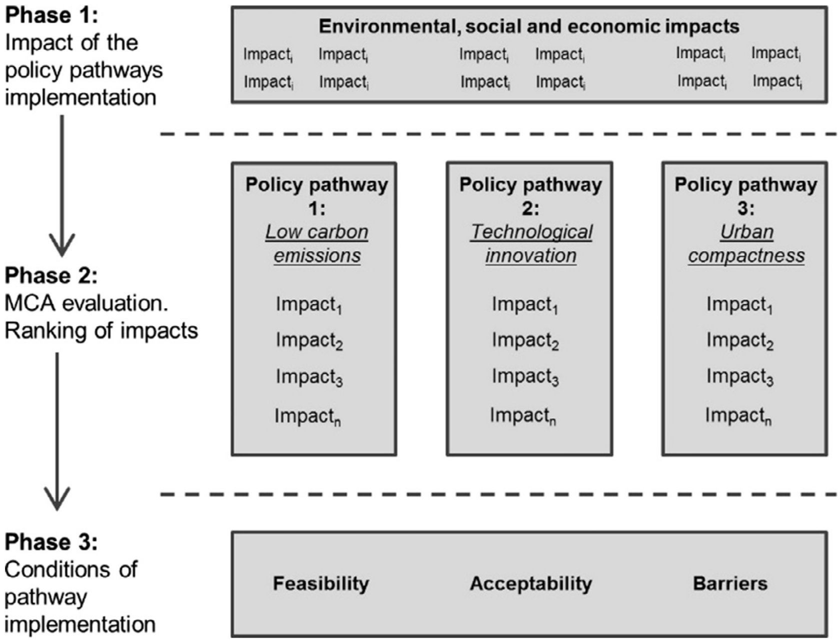

Fig. 3. Methodological framework.

3. Research design

The assessment of the wider sustainability impacts (environmental, social, and economic) and viability of the three different policy pathways (low carbon emissions, technological innovation and urban compactness) was structured according to three sequential phases, illustrating a "collaborative appraisal framework" where policy-makers were the main actors involved (Fig. 3). The first methodological phase reflects on the set of potential sustainability impacts that the three policy pathways could globally generate in comparison with Andalusia-BAU-projection. Those impacts were analysed in a qualitative way. The second phase focuses on ranking those impacts for each policy pathway using MCA techniques. The third phase explores the feasibility, acceptability and potential barriers of the three policy pathways, discussing how the previous issues can affect to the generation of the expected sustainability impacts.

A total of 36 policy-makers from regional and local governments in Andalusia took part in the research. Some participants (3–5) provided continuity between the three methodological phases. Local and regional policy-makers from Andalusia were asked to participate through an e-mail list, explaining to them the objective of the research and their necessary commitment. A total of 53 people initially stated that they were willing to participate in the research. An expertise matrix was used to select the final participants to ensure that each panel demonstrates adequate variation (e.g. local vs regional institutions, expertise, role in the institution, etc.). Finally, 36 policy-makers were confirmed to participate for reasons of sample variation.

3.1. Phase 1: the policy pathways' impacts

Phase 1 was operationalised through a workshop where policy-makers met face-to-face. The aim of the workshop was to discuss on potential sustainability impacts that the three described policy pathways could generate in comparison with the Andalusia-BAU-projection. To facilitate the discussion, the impacts were classified into three categories: (i) environmental; (ii) social; (iii) economic. The workshop did not identify specific sustainability impacts from the application of each policy pathway individually, but signalled sustainability impacts as a hypothetical result of applying the three policy pathways simultaneously.

A total of 15 participants took part in the workshop (7 of them from the regional government and the others from local government). An experienced transport consultant took on the role of mediator, and the researchers mainly acted as observers. The duration of the workshop was flexible, with approximately 5 h divided into three stages with two breaks. Section 4.1 summarises the results of this phase.

3.2. Phase 2: MCA evaluation and the ranking of impacts

A MCA framework was used to rank the potential impacts discussed during the previous phase for each policy pathway. To facilitate the ranking, pair-wise comparisons were used to determine the sustainability impacts for each of the three categories (environmental, social, and economic), analysing the capacity of each policy pathway to generate those impacts.

The Analytic Hierarchy Process (AHP) developed by Saaty (1987) was used. The AHP method has been widely used in the

Table 2
Nine point scale for pairwise comparison.

Likelihood that impacts can be generated by each policy pathway	Definition	Explanation
1	Equal likelihood	Two impacts equally have the same likelihood to be generated
3	Moderate likelihood	Experience and judgment slightly favour one impact over another
5	Strong likelihood	Experience and judgment strongly favour one impact over another
7	Very strong likelihood	An impact is favoured very strongly over another
9	Extreme likelihood	The evidence favouring one impact over another is the highest possible order of affirmation

transport field to rank transport alternatives in complex decision-making processes (Gardziejczyk and Zabicki, 2014; Gerçek et al., 2004). It is useful to elicit individual preferences that are then aggregated into a collective decision. It is used to derive ratio scales from both discrete and continuous paired comparisons of sustainability impact categories. These comparisons were taken from a nine-point scale, which reflects the relative strength of preferences and feelings of policy-makers on the likelihood that specific impacts from each category can be generated by policy pathways (Table 2). During the process, four pairwise matrices (relative environmental indicators, relative social indicators, relative economic indicators, and a combined matrix that compared environmental, social, and economic indicator in an aggregated way for each category) were obtained for each policy pathway and transformed into priority vectors. The combination of priority vectors provided weights to rank the impacts expected to be generated by each policy pathway (Tables 4–6).

Phase 2 was operationalised through a workshop where policy-makers met face-to-face. A total of 15 participants took part in the workshop. Five participants were common to Phase 1 so that continuity was ensured. The workshop was divided into two different steps: (i) The research team detailed the main purpose of the workshop, as well as explaining the Andalusia-BAU-projections, the desired future for the Andalusia transport sector, the three policy pathways designed to reach those futures, and the potential sustainability impacts provided during the first methodological phase. This step took about 60′. During this time, participants could talk with each other, as well as asking to the research team for clarification and other details; (ii) The research team distributed a questionnaire to each participant, so that the pair-wise comparison between potential impacts for each policy pathway could be completed. The questionnaire was divided into three different blocks, one for each policy pathway under evaluation. This step took about 40′. Although each participant could interact with each other, the questionnaire was filled in individually. The results from the questionnaire were collectively and anonymously processed, and the results are presented in Section 4.2.

3.3. Phase 3: pathway implementation: feasibility, acceptability, and barriers to policy pathway implementation

Phase 3 was operationalised through a workshop where policy-makers met face-to-face. The aim of the workshop was to discuss on feasibility, acceptability, and potential barriers of the three described policy pathways in the context of Andalusia. A total of 15 participants took part in the workshop (6 of them from the regional government and the rest from local government). Four participants were common to both Phase 1 and Phase 2 ensuring continuity in the discussions. An experienced transport consultant took on the role of mediator, and the researchers mainly acted as observers. The duration of the workshop was flexible, with approximately 5.5 h divided into three stages with two breaks.

The first part of the workshop (60′) was spent discussing the policy pathways' *feasibility*. Participants were informed that the concept of feasibility combined political and financial elements. It referred to the possibility that the policy pathways were implemented according to aspects such as: direct or indirect implementation from the institutional perspective, ease of communication, and financial implications. The second part of the workshop (60′) focused on the policy pathways' *acceptability*, interpreted as social acceptability. This reflected how Andalusian people might experience the implementation of each policy pathway. The third part of the workshop (60′) was based on the identification of implementation *barriers*.

4. Results

4.1. The policy pathways' impacts

The methodological Phase 1 was operationalised through a workshop where a total of 15 policy-makers met face-to-face. Supported by the mediator, the research team outlined the main purpose of the workshop, as well as explaining the Andalusia-BAU-projection, the desired future for the Andalusia transport sector, and the three policy trajectories designed to reach the desired futures. Participants were strongly encouraged to discuss the main sustainability impacts that the three policy pathways could generate in the region in comparison with the Andalusia-BAU-projection (Table 3). Participants were informed that their reflections should be made taking into consideration the hypothetical situation where the three policy pathways were simultaneously implemented in the region. The discussion was carried out according to three different types of impacts: (i) environmental; (ii) social; (iii) economic.

The first part of the workshop (70′) was aimed at discussing on environmental impacts. In the participants' views, "the three policy pathways were fundamentally orientated towards achieving a modal shift in Andalusia by 2050, focusing on the implementation of free-emissions transport modes". For this reason, they perceived relevant impacts on both CO_2 emissions and local pollutants emissions (NO_x, SO_x and PM_x). The level of noise originated by the transport sector was also seen as one of the most important impacts generated. However, participants disagreed on how to measure this impact. Four participants signalled the personal level of annoyance originating from the transport sector's noise as a convenient indicator, but the other participants perceived this indicator as being too subjective. The mediator provided several examples of how the impact of noise could be measured, and final consensus was reached on identifying the number of people/households affected by levels of noise above 55 dB (according to Andalusia's legal framework). Participants also discussed whether reductions in vibrations originated from the transport sector were a relevant impact. The option was finally rejected, as it was concluded that "the environmental impact assessment of transport projects in Andalusia rarely highlighted vibrations as a severe impact to be considered". The last two environmental impacts discussed by participants were: (i) the consumption of energy; (ii) the surface used by the transport sector at the city level. Participants strongly agreed that both impacts were very relevant in determining how the three policy pathways could re-orient the Andalusia-BAU-projection towards reaching sustainable outcomes. First, participants declared that reductions in the consumption of energy would not be achieved "due to the modal shift towards electric transport modes, such as electric cars and electric bikes, would highly increase the energy used by the transport sector". Secondly, changes on the street's surface used by transport modes at the city level were considered a crucial factor in the context of the policies implemented as part of the urban compactness pathway.

The second part of the workshop (70′) was aimed at discussing the social impacts. Participants felt really concerned about how the three policy pathways could reduce transport-related social exclusion problems originating from car dependence in Andalusia. They were very sceptical on the positive impact of the pathway "technological innovation", as it was strongly based on the promotion of electric vehicles. For this reason, participants agreed that the impact of the three policy pathways on the number of people in a position of transport-related social exclusion by 2050 was a key factor to be considered. Safety issues were also a focus of the discussion. The reduction of accidents from the transport sector was seen as one of the most important social contributions from scenarios in the longer-term. A high level of consensus was reached on the inclusion of two social indicators to assess transport scenarios: (i) reduction in the number of personal injury accidents; (ii) reduction in the number of accidents involving fatalities. The last part of the discussion on social impacts was focused on disabled people. Participants declared that "*the mobility of disabled people is one of the key missing elements in the transport sector. In this way, the impact of policy pathways should pay a considerable attention to this situation*".

The third part of the workshop (70′) was aimed at discussing the economic impacts. Participants considered that the most relevant economic impacts were based on accessibility issues. A high level of agreement was reached on the importance of accessibility to jobs and public facilities. It was unclear to participants whether the accessibility to retail stores should be an impact for assessment. One group of participants asserted that economic impacts should be only focused on jobs, and the accessibility to retail stores was more related to leisure issues. The rest of participants argued that improvements in accessibility to retail stores could activate economic

Table 3
Sustainability impacts of the three policy pathways.

Indicator	Comments/reasoning
Environmental impacts	
Reduction of CO_2 emissions by transport modes	Participants thought that the main differences between Andalusia-BAU-projection and the three policy pathways should be related to the level of emissions by transport modes at both global (CO_2) and local (NO_x, SO_x and PM_x) levels
Reduction of local emissions by transport modes (NO_x, SO_x and PM_x)	
Reduction of the number of households affected by noise (above 55 dB according to Andalusia legal framework)	Participants considered the noise as one of the most direct and negative effects by transport modes in Andalusian cities
Reduction of energy consumption by transport modes	It was unclear to participants whether the three policy pathways will have a positive impact on energy consumption by transport modes
Reduction of the surface used by transport modes at city level	It was considered that policy pathways implementation should have a relevant impact on recovering street space for socialisation. That means more non-motorised space in streets, spaces for children, older people, etc
Social impacts	
Reduction of population affected by transport-related social exclusion	The high use of private vehicles was seen as the main sources of the problem. In participant's views, policy pathways could reinforce this situation through the proposed implementation of electric and hybrid vehicles
Reduction of the number of personal injury accidents	There was unanimity in thinking that the number of accidents should be decreased through the implementation of the three policy pathways
Reduction of the number of accidents involving fatalities	
Reduction of disabled people affected by transport-related exclusion	There was unanimity in considering disabled people as a risky group related to transport-related exclusion. For this reason, the impact of policy pathways on this group of population was considered crucial to assess transport scenarios
Economic impacts	
Increase of accessibility to jobs	Participants agreed that accessibility to jobs, facilities and retail stores was key to assess the capacity of the policy pathway to improve economic issues
Increase of accessibility to facilities	
Increase of accessibility to retail stores	
Increase of journey time reliability	Participants considered that policy pathways should have a very positive impact on the journey time reliability in order to solve the existing problems of congestion in Andalusian cities

activity, and this could not only be seen as a leisure activity. It was finally agreed that the accessibility to retail stores should be included as an economic impact for assessment. During the last part of the workshop, participants agreed that another relevant economic impact to be considered should be the journey time reliability. In their opinion, "*this was very important due to the high levels of congestion in Andalusia, especially in metropolitan areas. For this reason, policy pathways should have a positive impact in this respect, reorienting Andalusia-BAU-projection*".

4.2. MCA evaluation and the ranking of impacts

This section summarises the ranking of sustainability impacts attributed to each policy pathway, and it is structured according to the three policy pathways under evaluation.

For the policy pathway "lower carbon emissions" (Table 4), policy-makers signalled a high capacity to generate environmental and economic impacts, while only a low capacity to create social impacts. This is mainly due to this policy pathway consisted fundamentally of the combination of *PP1 Low emission vehicles, PP4 Freight transport, and PP7 Non-motorised modes,* all of them associated with environmental impacts, as well as *PP5 Multi-modality* and *PP10 Infrastructure investments* mainly related to economic issues. From the environmental side, it is expected relevant reductions in CO_2 emissions, local pollutants, and noise, while low impact it is expected on reductions in energy consumption and the surface used by transport modes. The reasoning here is the high expectations about the substitution of traditional vehicles for electric ones. From the economic perspective, it is significant to see how the improvement of multi-modality (PP5) is perceived as crucial to reducing traffic congestion and increasing the journey time reliability. Finally, improvements on social issues are not highlighted by policy-makers. The explanation of that is related to the high level of transport-related social exclusion linked to car dependence in Andalusia, and the low expectation to change that through the implementation of this policy pathway.

The second policy pathway is "technological innovation" (Table 5). Participants highlighted the capacity of the pathway to generate positive environmental and economic impacts. However, there was only a low capacity to generate social impacts. Significant reductions on CO_2, local pollutions, and noise are expected, including improvements in the accessibility to jobs, facilities, and retail stores. *PP1 Low emission vehicles* and *PP2 ICT* are the main packages that integrate this pathway. In the participants' views, that means a policy scheme focused on technological penetration, where problems of transport-related social exclusion can be reinforced, primarily for several groups, such as the elderly population, low-income families, etc. Nevertheless, the capacity of this pathway was contested – and in particular *PP2 ICT* – to address issues related to improving journey time reliability. Small improvements are expected regarding energy consumption from the transport sector, but the city model would continue to focus on private vehicles and motorised mobility.

The third policy pathway was "urban compactness" (Table 6). Policy-makers perceived a high capacity of this policy scheme to generate positive impacts related to environmental and social issues, while economic impacts would be harder to generate. The implementation of the *PP6 liveable cities* seemed to have a strong influence in generating those impacts in the view of participants when compared with the other policy pathways. Drastic reductions in transport emissions (CO_2 and local pollutants) were seen as relevant impacts, together with reductions in the surface space used by transport modes and in the number of people affected by transport-related social exclusion. From the economic side, the priority given to non-motorised transport modes was not perceived as a positive issue for accessibility standards at city level (accessibility to facilities, jobs, and retail stores), while the combination of *PP6 liveable cities* and *PP5 multimodality* was perceived as crucial to increase journey time reliability.

Table 4
MCA results for policy pathway "Lower Carbon Emissions".

Categories of impacts	A	B	C			Weight
(A) Environmental	1	5	3			0.607
(B) Social	1/5	1	1/5			0.09
(C) Economic	1/3	5	1			0.303
Environmental impacts	A	B	C	D	E	Weight
(A) Reduction of CO_2 emissions by transport modes	1	1	1	5	7	0.304
(B) Reduction of local emissions by transport modes (NO_x, SO_x and PM)	1	1	1	5	7	0.304
(C) Reduction of the number of households affected by noise (above 55db)	1	1	1	5	5	0.285
(D) Reduction of energy consumption by transport modes	1/5	1/5	1/5	1	1	0.057
(E) Reduction of the surface used by transport modes at city level	1/7	1/7	1/5	1	1	0.05
Social impacts	A	B	C	D		Weight
(A) Reduction of the number of personal injury accidents	1	1	3	3		0.365
(B) Reduction of the number of accidents involving fatalities	1	1	3	3		0.365
(C) Reduction of disabled people affected by transport-related exclusion	1/3	1/3	1	3		0.172
(D) Reduction of Population affected by transport-related social exclusion	1/3	1/3	1/3	1		0.099
Economic impacts	A	B	C	D		Weight
(A) Accessibility to Jobs	1	1	1	1/3		0.166
(B) Accessibility to facilities	1	1	1	1/3		0.166
(C) Accessibility to retail stores	1	1	1	1/3		0.166
(D) Journey time reliability	3	3	3	1		0.5

*This table shows an average value of priority vectors for each impact, obtained from individual questionnaires on "Low Carbon Emissions". The combination of priority vectors provided the weights to rank those impacts.

Table 5
MCA results for policy pathway "Technological innovation".

Categories of impacts	A	B	C			Weight
(A) Environmental	1	5	1			0.48
(B) Social	1/5	1	1/3			0.115
(C) Economic	1	3	1			0.405
Environmental impacts	A	B	C	D	E	Weight
(A) Reduction of CO_2 emissions by transport modes	1	1	1	7	7	0.314
(B) Reduction of local emissions by transport modes (NO_x, SO_x and PM)	1	1	1	7	7	0.314
(C) Reduction of the number of households affected by noise (above 55 dB)	1	1	1	5	5	0.276
(D) Reduction of energy consumption by transport modes	1/7	1/7	1/5	1	1	0.048
(E) Reduction of the surface used by transport modes at city level	1/7	1/7	1/5	1	1	0.048
Social impacts	A	B	C	D		Weight
(A) Reduction of the number of personal injury accidents	1	1	5	3		0.399
(B) Reduction of the number of accidents involving fatalities	1	1	3	3		0.357
(C) Reduction of disabled people affected by transport-related exclusion	1/5	1/3	1	1/3		0.083
(D) Reduction of Population affected by transport-related social exclusion	1/3	1/3	3	1		0.161
Economic impacts	A	B	C	D		Weight
(A) Accessibility to Jobs	1	1	1	5		0.332
(B) Accessibility to facilities	1	1	1	3		0.291
(C) Accessibility to retail stores	1	1	1	3		0.291
(D) Journey time reliability	1/5	1/3	1/3	1		0.086

*This table shows an average value of priority vectors for each impact, obtained from individual questionnaires on "Technological Innovation". The combination of priority vectors provided the weights to rank those impacts.

Table 6
MCA results for Policy Pathway "Urban Compactness".

Categories of impacts	A	B	C			Weight
(A) Environmental	1	1	5			0.48
(B) Social	1	1	3			0.405
(C) Economic	1/5	1/3	1			0.115
Environmental impacts	A	B	C	D	E	Weight
(A) Reduction of CO_2 emissions by transport modes	1	1	5	5	1	0.289
(B) Reduction of local emissions by transport modes (NO_x, SO_x and PM)	1	1	5	5	1	0.289
(C) Reduction of the number of households affected by noise (above 55 dB)	1/5	1/5	1	1	1/5	0.058
(D) Reduction of energy consumption by transport modes	1/5	1/5	1	1	1/7	0.054
(E) Reduction of the surface used by transport modes at city level	1	1	5	7	1	0.310
Social impacts	A	B	C	D		Weight
(A) Reduction of the number of personal injury accidents	1	1	5	1/3		0.227
(B) Reduction of the number of accidents involving fatalities	1	1	5	1/3		0.227
(C) Reduction of disabled people affected by transport-related exclusion	1/5	1/5	1	1/3		0.079
(D) Reduction of Population affected by transport-related social exclusion	3	3	3	1		0.467
Economic impacts	A	B	C	D		Weight
(A) Accessibility to Jobs	1	1/3	1/3	1/3		0.098
(B) Accessibility to facilities	3	1	1	1/3		0.21
(C) Accessibility to retail stores	3	1	1	1/3		0.21
(D) Journey time reliability	3	3	3	1		0.481

*This table shows an average value of priority vectors for each impact, obtained from individual questionnaires on "Urban Compactness". The combination of priority vectors provided the weights to rank those impacts.

4.3. Feasibility, acceptability, and potential barriers of the policy pathways

The methodological phase 3 was operationalised through a workshop where a total of 15 policy-makers met face-to-face. This section summarises the main participants' views on the feasibility, acceptability, and potential barriers of the three policy pathways under evaluation: lower carbon emissions, technological innovation, and urban compactness (Table 7).

For the "lower carbon emissions" pathway, policy-makers signalled a medium-low feasibility, since "*the costs of PPs multi-modality and infrastructure investments could be very high*". According to participants' views, the investments in transport infrastructures during the last decades, including city-hubs, railway systems, and highways, have been substantial from regional and local governments. This reason would limit new budgets being allocated to implement this policy pathway. There was also consensus in thinking that the social acceptability of this policy pathway would be low. Participants thought that "*political corruption during the last decades associated with the development of transport infrastructures make it difficult that Andalusian population can accept this pathway in its present form*". In the view of participants, only "low cost" measures would recover the trust in political decisions. Finally, the coordination between local and regional governments was also seen by participants as a potential barrier to be overcome.

Table 7
Summary: feasibility, acceptability, and potential barriers of the policy pathways.

	Policy pathways		
	Lower carbon emissions	Technological innovation	Urban compactness
Feasibility	– Medium-low feasibility – Financial feasibility as hindrance – Non-feasible investments in new transport infrastructures – "Low cost" policies as a way to go forward	– High feasibility – Strong Andalusian agenda on digitalisation – International commitments to implement electric vehicles at city level	– Medium-high feasibility – Low cost policies – Policies easily implementable at urban level
Acceptability	– Low social acceptability – Andalusian population very critical with new investments in transport infrastructures, including multi-modality	– High social acceptability – Some concerns are related to elderly population	– High social acceptability – Some concerns are related to the reduction of space for private vehicles
Potential barriers	– Financial barriers are very relevant for PP5 multi-modality and PP10 infrastructures investments – Coordination between regional and local government as a hindrance	– Financial barriers orientated towards the implementation of electric vehicles – Need to increase the social awareness of technological innovations	– Financial barriers orientated towards the implementation of policies on multi-modality and non-motorised modes – Need to increase the social awareness of the use of non-motorised modes

For the "technological innovation" pathway, high feasibility was perceived. On the one hand, regional policy-makers highlighted that the Andalusian government is promoting an ambitious digitalisation agenda that includes transport issues. Moreover, a substantial budget is expected in upcoming years to achieve this objective that would strongly benefit the implementation of *PP2 ICT*. On the other hand, participants mentioned that European directives and Andalusian international commitments are orientated towards a transition from conventional to electric vehicles. For these reasons, it is thought that the feasibility of this pathway at political and financial levels is high. Social acceptability is also expected to be high. Local policy-makers underlined acceptability problems from the elderly population, who can see the technological penetration in the transport sector as a potential problem for transport-related social exclusion in the future. Finally, local policy-makers agreed that "*there were important financial barriers from Andalusian local institutions to facilitate the implementation of electric and hybrid modes*". Another barrier seen was the need to promote actions to increase the social awareness of the need to implement technological innovation in the Andalusian transport sector.

For the "urban compactness" pathway participants indicated a medium-high feasibility. They declared that most of policies that integrated the *PP6 liveable cities* were "low cost", and easily implementable at the city level. Problems were seen with the implementation of PPs such as *PP5 multi-modality* and *PP7 non-motorised modes*, which were recognised as being more expensive. Social acceptability is expected to be high according to the view of participants. They signalled that "*previous experiences to make more liveable cities in Granada, Malaga, and Sevilla were positively seen by citizens*". Nevertheless, policy-makers also indicated that "*problems in the shorter-term can arise due to the reduction of space dedicated to private vehicles. However, this situation is expected to change in the longer-term when more liveable cities are experienced by citizens*". Together with financial issues, policy-makers declared that the main barriers for implementation can be related to traffic management issues, as well as the need to promote strong social awareness campaigns in favour of non-motorised transport modes.

5. Conclusions

While the academic literature has produced promising theories and innovations on the phases of "visioning" and "policy-packaging" in transport backcasting studies, the evaluation of the impacts associated with those transport scenarios has been rarely addressed. Furthermore, limited attention has been paid to the role that stakeholders could have in evaluating the potential impacts of transport backcasting scenarios, as one means to bridge the implementation gap between research and effective action (Banister and Hickman, 2013). In order to bridge this theory-practice gap, we have developed and implemented a "collaborative appraisal framework" for transport backcasting studies. It has focused on the application of MCA in combination with participatory approaches based on face-to-face workshops.

This has resulted in three major contributions regarding the state-of-the-art in the field. First, the "appraisal phase" of backcasting has been presented here as one additional step in the scenario-building process and it is seen as being of equivalent relevance to the other backcasting phases (e.g. visioning and policy-packing) (Hickman et al., 2012). Since the "appraisal phase" has been fundamentally focused on assessing implementability, values, and barriers, the academic exercise of backcasting has been balanced with a more critical reflection on practical implementation issues through policy-makers' eyes. Second, the paper has used a more unstructured appraisal phase, combining different participatory approaches (from face-to-face workshops to MCA analysis), where policy-makers have been encouraged to actively participate, and this participation is seen as being a central element for backcasting implementation in collaborative planning schemes (Soria-Lara and Banister, 2018). Third, a representative group of Andalusian policy-makers from different institutions (local, regional, sectorial, etc.) has been involved throughout the "appraisal phase. Given their capacity, knowledge and experience to anticipate the real consequences of transport scenarios, a more 'realistic' perspective on

future implementation can be made. (Mattila and Antikainen, 2011).

The designed framework has been operationalised in a sequential process, involving researchers (as observers) and policy-makers (as actors responsible for transport-policy implementation). The context of the transport sector in Andalusia (Spain) has been used as a case study, providing a clear illustration of the process. Four main conclusions are drawn:

1. Relevance: The "collaborative appraisal framework" for transport backcasting studies has been presented here as being central in both the scenario building and the policy-making processes. The capacity to achieve positive sustainability outcomes in the Andalusia's transport sector has been assessed against multiple policy goals (environmental, social, and economic), as well as the feasibility, social acceptability, and potential barriers of a set of policy trajectories (lower carbon emissions, technological innovation, and urban compactness). In this respect, the use of MCA techniques has been a highly effective means to weigh the potential sustainability impacts of each policy pathway in terms of their likelihood of being generated.
2. Structure: The involvement of actors during the backcasting process is seen as an effective way to link academia with transport practice. This research has used a bottom-up approach that has involved a wide range of policy-makers from both regional and local governments in Andalusia. This has resulted in the creation of a more democratic means to assess the sustainability impacts and viability of transport backcasting scenarios in Andalusia, rather than the traditional deliberative process involving a more restricted group of actors. Only policy-makers were involved in the assessment process, as they are responsible for the implementation of transport-policy schemes in the region. In the complementary studies, a wider range of stakeholders and professional actors have been involved (Soria-Lara and Banister, 2017a; 2017b). Nevertheless, important barriers are present in the Andalusia context to the implementation of a bottom-up approach, due to institutional and legal constraints that encourage more top-down and technocratic approaches.
3. Learning processes: The "appraisal phase" can be also seen as a learning process helping to refine policy trajectories iteratively. The "collaborative appraisal phase" implemented in this research has followed a sequential process, where different groups of policy-makers have built their views on the sustainability impacts and viability of transport backcasting scenarios in collaboration with other policy-makers. This has resulted in a collective process of knowledge generation that contrasts with other participatory backcasting studies non-sequentially implemented (Marchau and Van der Heiden, 2003; Tuominen et al., 2014). This participatory approach has worked well in the context of Andalusia. Part of the success is attributed to the continuity of the core participants throughout the different sequential phases, allowing clarifications of the choices made in previous steps. A crucial aspect here is avoiding the domination of the discourse by a core group of participants. The mediator has an important responsibility in this respect, and he/she must be strongly encouraged to stop the discussion if this situation occurs. During the research process this possibility has been limited through the MCA operationalisation, as this has contributed to the avoidance of one dominant discourse. MCA has provided a valuable tool for the mediator and the research team. The MCA questionnaire was individually filled in (although participants could interact at other times), and the results were collectively and anonymously processed by the research team. Furthermore, MCA application has also contributed to providing additional insights to policy-makers that formed the basis for workshop discussions on policy pathways implementation, reinforcing the strengths of this "collaborative appraisal phase" as a learning process. Finally, this research has highlighted the capacity of the "collaborative appraisal phase" to make recommendations that can be used to refine the policy pathways. For example, recurrent recommendations were made to re-orient policy packages towards a set of "low cost" measures, as well as understanding how policy-makers constantly referred to potential changes in legislation, and in the time necessary for implementation.
4. Policy integration: The assessment of transport backcasting scenarios in Andalusia – and in particular the results from MCA analysis – has revealed how an integrated approach to transport policy-making is seen as being fundamental to the achievement of significant progress towards sustainable transport futures. This includes behavioural changes, alternative fuels, technological penetration, energy efficiency, and other policy interventions. The implementation of a wide range of policy options and policy trajectories is essential when environmental, social, and economic goals need to be reached. An important issue here is the determination of the level of responsibility of different sectors (public institutions, private companies, citizens, etc.) in implementing such policy options, as well as identifying synergies and contradictions between policy alternatives. The case of Andalusia has shown how policy-makers have underlined the need to establish coordination panels between institutions, the private sector, and citizens as part of a successful transport-policy implementation process.

The above-detailed conclusions permit reflection on main advantages of following this "appraisal collaborative framework" in comparison with other more traditional methods. First, MCA has been used as an instrument to explore relative impacts and to provide policy-makers with additional insights for discussion. This approach contrasts with the use of MCA as a support instrument that validates choices made and generates rankings on which options and policy pathways are better or worse for sustainability (Lambert et al., 2012; Wang et al., 2014). In this respect, tools initially rooted in rationalistic approaches (e.g. MCA) have been applied to the more complex and flexible schemes associated with sustainable transport futures, thus proving its usefulness and effectiveness under collaborative approaches where stakeholders and different professional domains interact continuously. Second, implementation issues have been discussed on different policy pathways, and this has been carried out through the policy-makers' eyes, assuming they have the expertise to anticipate the consequences of particular policies. They also have a unique perspective on understanding the barriers and the effectiveness of different actions, as well as the interactions with complementary policy actions in other sectors. However, discussion on policy-pathways implementation is normally limited in backcasting studies in the transport field (Ashina et al., 2012; Schade and Schade, 2005; Winyuchakrit et al., 2011), and policy-makers are rarely core to the debates, and are often only involved at the end of the analysis process and not throughout (Tuominen et al., 2014; Zubaryeva et al., 2012b).

The main contribution of the paper has been at methodological level through the design and implementation of the "collaborative appraisal framework". While the Andalusia region (Spain) has served as spatial laboratory, methodological lessons learnt tend to be universal and applicable to multiple contexts where the transport planning process are influenced by complex policy options. The proposed "collaborative appraisal framework" would need to be customised for each particular situation, providing "unique experiences". Factors affecting to the application of the "collaborative appraisal framework" would include: time, cost, cultural traditions, level of participatory-oriented education, and many other factors.

This paper brings together a series of three publications aimed at gaining insights into the implementation of open-ended and participatory approaches during the three phases of the transport backcasting process: (i) Visioning (Soria-Lara and Banister, 2017a); (ii) Policy packaging (Soria-Lara and Banister, 2017b); (iii) Appraisal (this paper). The context of Andalusia was taken as spatial laboratory for experimentation, and this location has been held constant across all three papers. New challenges have arisen during the research process that has in turn led to progress towards a new generation of transport policy scenarios that address sustainability and low carbon futures. A set of new theoretical and practical foundations have been developed that are more democratic, accountable, and collaborative, and are based on bottom-up participation. These have also been embedded in institutional planning processes that are orientated towards more integrated and adaptive policy pathways, as well as being sensitive to social inequalities. This is the true meaning of collaborative and participatory processes in decision making.

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